PROCEEDINGS

OF

THE ROYAL SOCIETY.

1838. No. 36.

December 6, 1838.

JOHN W. LUBBOCK, Esq., V.P. and Treas., in the Chair.

Richard Charnock, Esq., was balloted for, but not elected into the Society.

The Rev. Philip Kalland, M.A., was balloted for, and duly elected into the Society.

A paper was in part read, entitled, "Experimental Researches in Electricity." *Fifteenth Series.*—"Note of the Character and Direction of the Electric Force of the Gymnotus." By Michael Faraday, Esq., D.C.L., F.R.S., &c.

December 13, 1838.

The MARQUESS of NORTHAMPTON, President, in the Chair.

The reading of a paper, entitled, "Experimental Researches in Electricity." *Fifteenth Series.*—"Note of the Character and Direction of the Electric Force of the Gymnotus." By Michael Faraday, Esq., D.C.L., F.R.S., &c., was resumed and concluded.

The author first briefly refers to what has been done by others in establishing the identity of the peculiar power in the Gymnotus and Torpedo with ordinary electricity, and then in reference to the intended conveyance to this country of Gymnoti from abroad, gives the instructions which he himself had received from Baron Humboldt for that purpose. A living Gymnotus, now in the possession of the Proprietors of the Gallery of Science in Adelaide Street, was placed for a time at the disposal of the author for the purpose of research, upon which he proceeded, with suitable apparatus, to compare its power with ordinary and voltaic electricity, and to obtain the direction of the force. Without removing it from the water he was able to obtain not only the results procured by others, but the other electrical phenomena required so as to leave no gap or deficiency in the evidence of identity. The shock, in very varied circumstances of position, was procured: the galvanometer affected; magnets were made; a wire was heated; polar chemical decomposition was effected, and the spark obtained. By comparative experiments made with the

animal and a powerful Leyden battery, it was concluded that the quantity of force in each shock of the former was very great. It was also ascertained by all the tests capable of bearing on the point, that the current of electricity was, in every case, from the anterior parts of the animal through the water or surrounding conductors to the posterior parts. The author then proceeds to express his hope that by means of these organs and the similar parts of the Torpedo, a relation as to *action* and *re-action* of the electric and nervous powers may be established experimentally; and he briefly describes the form of experiment which seems likely to yield positive results of this kind.

December 20, 1838.

JOHN GEORGE CHILDREN, Esq., V.P., in the Chair.

Prof. Louis Agassiz, and Prof. Carl. Fred. Philip von Martius, were severally elected Foreign Members of the Society.

A paper was read, entitled, "On the Curvature of Surfaces." By John R. Young, Esq. Communicated by John W. Lubbock, Esq., M.A., V.P. and Treas. R.S.

The principal object of this paper is, to remove the obscurity in which that part of the theory of the curvature of surfaces which relates to umbilical points has been left by Monge and Dupin, to whom, however, subsequently to the labours of Euler, we are chiefly indebted for a comprehensive and systematic theory of the curvature of surfaces. In it the author shows, that the lines of curvature at an umbilic are not, as at other points on a surface, two in number, or, as had been stated by Dupin, limited; but that they proceed in every possible direction from the umbilic.

The obscurity complained of is attributed to the inaccurate conceptions entertained by Monge and Dupin, of the import of the symbol $\frac{0}{0}$ in the analytical discussion of this question, the equation which determines the directions of the lines of curvature taking the form

$$0\left(\frac{dy}{dx}\right)^2 + 0\left(\frac{dy}{dx}\right) + 0 = 0$$

at an umbilic. After stating that Dupin has been guided by the determination of the differential calculus, the author remarks, that in no case is the differential calculus competent to decide whether $\frac{0}{0}$, the form which a general analytical result takes in certain particular hypotheses, as to the arbitrary quantities entering that result, has or has not innumerable values. He then states the principle, that those values of the arbitrary quantities (and none else) which render the equations of condition indeterminate must also render the final re-

sult, to which they lead, equally indeterminate; and that, therefore, when such result assumes the form $\frac{0}{0}$, its true character is to be tested by the equations that have led to it, after these have been modified by the hypothesis from which that form has arisen.

In a "Mémoire sur la Courbure des Surfaces," (Journal de l'École Polytechnique, Tom. XIII.), Poisson has arrived at the conclusion, that the number of lines of curvature passing through an umbilical point is infinite, and that those selected by Dupin differ from the others only by satisfying an additional differential equation; those others equally satisfying the conditions of a line of curvature. These are precisely the conclusions arrived at by the author. As, however, he considers that the mode of investigation pursued by Poisson is peculiar and ill adapted to the objects apparently in view, namely, to reconcile the results of Monge and Dupin and to remove their obscurities, he was induced to investigate some of the more important properties of curve surfaces, by a method somewhat different from that usually employed.

Adopting
$$Z = F(X, Y)$$
as the general equation of any surface; by attributing to X, Y, Z, increments x, y, z, and assuming that the axis Z coincides with the normal to the surface, or that the plane $x\,y$ is parallel to the tangent plane, an equation equivalent to, and nearly identical with, Dupin's equation of his indicatrix, is readily deduced. From this are immediately derived some properties of the radii of curvature, first shown by Dupin; and likewise the theorem of Meusnier. The author then enters upon the subject of the lines of curvature.

From the equations
$$A = 0, \qquad B = 0,$$
of the normal to the surface at a point on it, the equations of the normal at a point near to the former are determined. That these normals may intersect, which is the condition giving the directions of the lines of curvature, the two sets of equations must simultaneously exist; and hence are deduced the differential equations of condition for the lines of curvature,

$$\frac{d\,A}{d\,x} + \frac{d\,A}{d\,y} \cdot \frac{d\,y}{d\,x} = 0, \qquad \frac{d\,B}{d\,x} + \frac{d\,B}{d\,y} \cdot \frac{d\,y}{d\,x} = 0.$$

By this method, which fundamentally is not very different from that of Monge, substituting the usual expressions for A and B, the equation that determines the directions of the lines of curvature is deduced, in the form in which it had been previously given by Monge and Dupin.

This final equation becoming at an umbilic of the form,

$$0\left(\frac{d\,y}{d\,x}\right)^2 + 0\left(\frac{d\,y}{d\,x}\right) + 0 = 0,$$

in which $\frac{d\,y}{d\,x}$ *may* be indeterminate, the author inquires how this in-

determinate form will affect the equations of condition. As by this supposition, these are reduced to equations from which would result the conditions that would render all the coefficients of the determining equation 0, it is inferred that $\frac{dy}{dx}$ *must* be indeterminate, and that therefore, at an umbilic there issue lines of curvature in all directions.

Of these lines of curvature, it is possible that some may be distinguished from others, by proceeding from the point in more intimate contact with the osculating sphere, and it is therefore necessary to determine the analytical character of such particular lines of curvature. With this view, the author resumes the equation of the normal in the immediate vicinity of the umbilic. He then points out, that a straight line, whose equations contain the second differential coefficients, thus involving a new condition, will coincide more nearly with this normal, than can any straight line not having that condition. That the lines may intersect in the centre of the osculating sphere, their equations must simultaneously exist; and thus, that which most nearly coincides with the normal in the immediate vicinity of the umbilic has the new conditions,

$$\frac{d^2 A}{d x^2} + 2 \frac{d^2 A}{d x \, d y} \cdot \frac{d y}{d x} + \frac{d^2 A}{d y^2} \cdot \frac{d y^2}{d x^2} = 0,$$

$$\frac{d^2 B}{d x^2} + 2 \frac{d^2 B}{d x \, d y} \cdot \frac{d y}{d x} + \frac{d^2 B}{d y^2} \cdot \frac{d y^2}{d x^2} = 0,$$

in addition to the former ones.

From this it appears, that when the direction of a line of curvature issuing from an umbilic is such as to fulfil, besides the ordinary conditions, the foregoing new conditions, that line of curvature will lie more closely to the osculating sphere than any other not satisfying these additional equations. These new conditions arise from differentiating the preceding ones with respect to x and y, considered as dependent, regarding $\frac{dy}{dx}$ as constant; and as these are equivalent to a single condition (Monge's and Dupin's equation) it will be sufficient to differentiate this, under the above restrictions, in order to obtain a single condition equivalent to the new ones. As this single condition will appear under the form of an equation of the third degree in $\frac{dy}{dx}$, there will, in general, be at least one line of curvature, proceeding from the umbilic, of more than ordinary closeness to the osculating sphere; and there may be three. If, indeed, this equation of the third degree should, like that of the second from which it is deduced, be identical for the coordinates of the umbilic, it is obvious from the investigation, that we must then proceed to another differentiation; and so on, till we arrive at a determinate equation, the real roots of which will make known the number and directions of the lines of closest contact.

When, however, the author remarks in conclusion, all the lines of curvature issuing from the umbilic are equally close to the osculating sphere, then these successive differentiations will either at length exhaust the coefficients, and thus no determinate equation will arise; or else they will conduct to an equation whose roots are all imaginary: and one or other of these circumstances must always take place at the vertex of a surface of revolution.

The Society adjourned over the Christmas Recess to meet again on the 10th January next.

January 10, 1839.

JOHN WILLIAM LUBBOCK, Esq., V.P. and Treas., in the Chair.

William James Frodsham, and John Hilton, Esquires, were severally elected Fellows of the Society.

A paper was read, entitled, "On the Laws of Mortality." By Charles Jellicoe, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

The author, considering that the variations and discrepancies in the annual decrements of life which are exhibited in the tables of mortality hitherto published would probably disappear, and that these decrements would follow a perfectly regular and uniform law, if the observations on which they are founded were sufficiently numerous, endeavours to arrive at an approximation to such a law, by proper interpolations in the series of the numbers of persons living at every tenth year of human life. The method he proposes, for the attainment of this object, is that of taking, by proper formulæ, the successive orders of differences, until the last order either disappears, or may be assumed equal to zero. With the aid of such differences, of which, by applying these formulæ, he gives the calculation, he constructs tables of the annual decrements founded principally on the results of the experience of the Equitable Assurance Society.

January 17, 1839.

JOHN FORBES ROYLE, M.D., V.P., in the Chair.

Beriah Botfield, and Peter Hardy, Esquires, were severally elected Fellows of the Society.

A paper was read, entitled, "On the state of the Interior of the Earth." By W. Hopkins, Esq. A.M., F.R.S., Second Memoir. "On the Phenomena of Precession and Nutation, assuming the Fluidity of the Interior of the Earth."

In this memoir the author investigates the amount of the luni-solar precession and nutation, assuming the earth to consist of a solid spheroidal shell filled with fluid. For the purpose of presenting the problem under its most simple form, he first supposes the solid shell to be bounded by a determinate inner spheroidal surface, of which the ellipticity is equal to that of the outer surface; the change from the solidity of the shell to the fluidity of the included mass being, not gradual, but abrupt. He also here supposes both the shell and the fluid to be homogeneous, and of equal density. The author then gives the statement of the problem which he proposes to investigate; the investigation itself, which occupies the remainder of the paper, being wholly analytical, and insusceptible of abridgement. The following, however, are the results to which he is conducted by this laborious process: namely, that, on the hypothesis above stated, 1. The Precession will be the same, whatever be the thickness of the shell, as if the whole earth were homogeneous and solid. 2. The Lunar Nutation will be the same as for the homogeneous spheroid to such a degree of approximation that the difference would be inappreciable to observation. 3. The Solar Nutation will be sensibly the same as for the homogeneous spheroid, unless the thickness of the shell be very nearly of a certain value, namely, something less than one quarter of the earth's radius; in which case this nutation might become much greater than for the solid spheroid. 4. In addition to the above motions of precession and nutation, the pole of the earth would have a small circular motion, depending entirely on the internal fluidity. The radius of the circle thus described would be greatest when the thickness of the shell was the least: but the inequality thus produced would not, for the smallest thickness of the shell, exceed a quantity of the same order as the polar nutation, and for any but the most inconsiderable thickness of the shell would be entirely inappreciable to observation.

In his next communication, the author purposes considering the case in which both the solid shell and the inclosed fluid mass are of variable density.

"Apperçu sur une manière nouvelle d'envisager la théorie cristallographique dans le but d'établir les rapports de celle-ci avec la forme sphérique, ou elliptique, des molécules, ainsi qu'avec l'effet des milieux sur la forme cristalline." Par M. L. A. Necker. Communicated by P. M. Roget, M.D., Sec. R.S.

In this communication, after adverting to Haüy's theory of crystallization, in which the molecules are considered to be polyhedrons, to the views subsequently taken by Wollaston and Davy, and particularly to Brewster's conclusions, that there ought to be different forms of molecules, some spherical, some elliptical with two equal axes, and a third unequal to these, and others elliptical with three unequal axes; M. Necker states, that Mr. Dana is the only mineralogist who has attempted to introduce into crystallography the consideration of molecules with curved surfaces. Although, adopting the forms proposed by Brewster, and adding to them those

of oblique solids, by introducing the idea of polarity in the axes of crystallization, Mr. Dana has successfully applied this molecular theory to crystallography, yet he goes no farther; and the most important and difficult steps in this branch of physical science still remain to be made, and many phenomena in crystallization, with the cause of which we are at present wholly unacquainted, still require to be explained by the theory. The author particularly refers to the important facts discovered by MM. Leblanc and Beudant, of the influence that solutions or mediums in which bodies crystallize have on the secondary forms which these bodies take; and states, that the present views of crystallography afford not even a glimpse of the least relation between such forms and the properties of the mediums. Why, he asks, does pure water appear, in general, to tend to simplify the forms, precisely as do certain mixtures, those of chlorite in axinite, quartz, felspar, &c., and why, on the contrary, do other mediums, acid or earthy, complicate them?

Impressed with the importance which must attach to the solution of such questions, M. Necker offers some ideas which long meditation on this important subject has suggested to him.

Adopting the ellipsoid as the form of the molecule, he remarks, that the more complicated the form of the crystal, the more the number of its faces increases, and the more, at the same time, does it approach to the ellipsoidal form of the molecule; and, on the contrary, the simpler the form becomes, the more does it recede from that with a curved surface. All crystalline forms may be considered as making a part of one or more series, which, in each system of crystallization, have for extreme terms, on the one side, the most simple solid of the system, or that which has the least number possible of faces, and on the other, the solid having the greatest number, namely a sphere or an ellipsoid. Although it is more convenient in the calculation of forms to start from the most simple polyhedral forms in order to arrive at the more complex, nothing proves that such has been the route which nature has followed. As long as we considered the integral molecules as polyhedral, it appeared natural to view them as grouping in polyhedrons; but when once we cease to admit polyhedral molecules, it then becomes most natural to suppose, that ellipsoidal molecules should have a tendency, more or less decided, to group in solids of the same form as themselves, when no extraneous circumstances interpose an obstacle to this tendency.

In order to give an idea of the kind of effect which would be produced on the form of the solid by these obstacles, such as the nature of the medium in which crystallization takes place, a hurried or tumultuous crystallization, &c., the author conceives that each molecule, as well as each solid formed by their union, has different axes of attraction, endued with different degrees of energy, and symmetrically disposed in groups, the weaker and the most numerous round the stronger, which are, at the same time, the smallest in number; all, in short, symmetrically arranged around the principal axes of crystallization, which are the most energetic of all. Thus we shall conceive that sort of polarity by which crystallization is distin-

guished from molecular attraction. The effect of obstacles, such as the attraction exerted by mediums, by interposed bodies, by the molecular attraction of the molecules themselves, when they arrive both in too great numbers and too rapidly towards the same point, will be the annihilation of the weaker axes; whence will follow the formation of a tangent plane to the spherical or elliptical surface. If the action of the obstacle goes on increasing, axes of attraction, which, by their intensity, had resisted the first obstacles, are destroyed by the new ones; and new tangential planes are produced, in which those that had been first formed finish by being confounded: thus it will happen that, by the increase of obstacles, the surface of the solid from being curved has become polyhedral, and finishes by presenting only an assemblage of a small number of plane faces, separated by edges, and placed tangentially at the extremity of the axes whose forces have longest resisted the action of the obstacles. But since the most energetic axes are necessarily the least numerous, the greater the energy they possess, the number of faces which bound the solid will continually decrease according as the obstacles increase; until, at length, the solid, reduced to its most simple form, no longer presents any but that constituted by the principal axes of crystallization, terminating at the summits of the solid angles of the simple polyhedron, which axes alone have been capable of withstanding the action of all the obstacles opposed to the tendency of the molecules to unite in the form of an ellipsoid.

On this hypothesis, the author explains how common salt, alum, sulphate of iron, &c., crystallize in pure water in the most simple forms, the reciprocal attraction of their molecules being controlled and diminished by the affinity exerted on them by the molecules of the water; whilst if some of these molecules of water are neutralized by mixture with another soluble principle, they cease to act as an obstacle to the crystallization of the body, which then takes forms more complicated and approaching nearer to that of the normal solid with a curved surface.

M. Necker considers that the new views he has sketched require, for their complete developement, many ulterior details, as well as many new experiments and new facts; but that the tendency which the crystals of all systems present, to progress towards the curved surface form appropriate to each system, by the complication of their forces, is a fundamental fact of the first importance; and that an advance has been made by showing the bearing of the important experiments of MM. Leblanc and Beudant, and by having brought the theory of crystallography nearer to those views which the progress of chemistry and of physics have led us to adopt, relative to the form of the elementary molecules of bodies.

January 24, 1839.

FRANCIS BAILY, Esq., V.P., in the Chair.

Charles Darwin, Esq., was elected a Fellow of the Society.

A paper was read, entitled, "Experiments made on a piece of Peña silver, saved from the Lady Charlotte, wrecked on the coast of Ireland in December 1838, as to its capability of holding water." By W. D. Haggard, Esq. Communicated by Sir Henry Ellis, K.H., F.R.S.

Plata Peña, so called, is silver collected by quicksilver after the ore is pounded; it is then placed in a mould, and by great force the quicksilver is squeezed out, when it forms a mass, resembling dry mortar, of great porosity.

	Troy Weight. lbs.	oz.	dwts.	Decrease in weight. lbs.	oz.	dwts.
Original weight when taken from the box	38	10	0			
One day placed before the fire	37	0	15	1	9	5
Third day	35	5	0	1	7	0
Fifth day	34	5	5	0	11	15
Eighth day	34	0	2	0	5	3
Weight of water				4	9	3

	lbs.	oz.	dwts.	Increase in weight. lbs.	oz.	dwts.
Weight of the piece supposed to be quite dry	34	0	2			
First day from the fire	34	0	3	0	0	1
Third day	34	2	5	0	2	2
Fifth day	34	4	2	0	1	17
Eighth day	34	4	9	0	0	7
Gained in water from the air				0	4	7
Weight after water had been forced into it	39	1	19	4	9	10
Total weight of water contained in the piece				5	1	17

A paper was also read, entitled, "On the Application of the Conversion of Chlorates and Nitrates into Chlorides, and of Chlorides into Nitrates, to the determination of several equivalent numbers." By Frederick Penny, Esq. Communicated by H. Hennell, Esq. F.R.S.

The researches which form the subject of this paper were suggested by an inquiry into the most effectual method of ascertaining the quantity of nitrate of potassa existing in crude saltpetre. The author found that by the action of hydrochloric acid the nitrate of potassa was converted into the chloride of potassium; and conversely, that the chloride of potassium might, by the proper regulation of the temperature, be reconverted into the nitrate of potassa by the action of nitric acid. These mutual conversions afforded excellent means of determining, with great exactness, the relative equivalent numbers, in the theory of definite proportions, belonging to these salts, and to their respective constituent elements. The author, accordingly, pursued the investigation of these numbers by several successive steps, of which the details occupy the greater part of the present paper. He first determines the equivalent of chloride of potassium by decomposing chlorate of potassa into oxygen and chlo-

ride of potassium; the proportion between which gives the ratio which the respective equivalent numbers of each bear to one another, and also to that of chlorate of potassa. The equivalent of nitrate of potassa is next obtained by converting the chlorate and the chloride of potassium into that salt; and from these data the equivalents of chlorine and of nitrogen are deduced. A similar train of inquiry is next instituted with the corresponding salts having sodium for their base: chlorate of soda being decomposed into the chloride, and into the nitrate; nitrate of soda into chloride; and chloride of sodium into nitrate of soda. The results of these different series of experiments coincide so closely with one another as mutually to confirm their general accuracy in the most satisfactory manner. For the purpose of determining the equivalent numbers of the elementary bodies themselves, (namely, chlorine, nitrogen, potassium, and sodium,) the author employed the intermedium of silver, the several saline combinations of which with chlorine and with nitric acid were found to afford peculiar advantages for the accurate determination of the relative weights of the constituents of these salts, when subjected to various combinations and decompositions. The conclusions to which the author arrives with regard to the equivalent numbers for the six elementary bodies in question, tend to corroborate the views of the late Dr. Turner, and to overturn the favourite hypothesis that all equivalent numbers are simple multiples of that for hydrogen. He finds these numbers to be as follow:

Oxygen	8·
Chlorine	35·45
Nitrogen	14·02
Potassium	39·08
Sodium	23·05
Silver	107·97

The author intends to pursue these inquiries, by applying similar methods to the investigation of other classes of salts.

January 31, 1839.

JOHN W. LUBBOCK, Esq., Vice-President and Treas., in the Chair.

John Wesley Williams, and James Yates, Esqrs., were severally elected Fellows of the Society.

A paper was read, entitled, "Some account of the Art of Photogenic Drawing, or the Process by which Natural Objects may be made to delineate themselves without the aid of the Artist's Pencil." By H. F. Talbot, Esq., F.R.S.

In this communication the author states, that during the last four or five years he has invented and brought to a considerable degree

of perfection, a process for copying the forms of natural objects by means of solar light, which is received upon paper previously prepared in a particular manner. He observes, that a prior attempt of this kind is recorded in the Journal of the Royal Institution for 1802; by which it appears that the idea was originally suggested by Mr. Wedgwood, and afterwards experimented on by Sir Humphry Davy. These philosophers found, that their principle, though theoretically true, yet failed in practice, on account of certain difficulties; the two principal of which were: *first*, that the paper could not be rendered sufficiently sensible to receive any impression whatever from the feeble light of a camera obscura; and *secondly*, that the pictures which were formed by the solar rays could not be preserved, owing to their still continuing to be acted upon by the light.

The author states that his experiments were begun without his being aware of this prior attempt; and that in the course of them he discovered methods of overcoming the two difficulties above related. With respect to the latter, he says, that he has found it possible by a subsequent process, so to fix the images or shadows formed by the solar rays, that they become insensible to light, and consequently admit of being preserved during any length of time: as an example of which, he mentions, that he has exposed some of his pictures to the sunshine for the space of an hour, without injury.

With respect to the other point, he states that he has succeeded in discovering a method of preparing the paper which renders it much more sensitive to light than any which had been used previously; and by means of which he finds, that there is no difficulty in fixing the pictures given by the camera obscura and by the solar microscope.

He states that in the summer of 1835 he made a great number of portraits of a house in the country of ancient architecture, several of which were this evening exhibited to the Society.

After some speculations on the possibility of discovering a yet more sensitive paper, the author mentions, that the kind employed by him may be rendered so much so, as to become visibly affected by the full light of the sun, in the space of half a second.

The rest of this paper contains an account of various other ways in which this method may be employed in practice, according to the kind of object which it is required to copy: also, a brief mention of the great variety of effects resulting from comparatively small differences in the mode of preparation of the paper: and, of certain anomalies which occur in the process, the cause of which has not hitherto been rendered distinctly manifest.

In conclusion, the author designates this as "a new process, which he offers to the lovers of science and nature."

February 7, 1839.

The MARQUESS of NORTHAMPTON, President, in the Chair.

James Heywood, Esq., and the Rev. Henry Moseley, M.A., were severally elected Fellows of the Society.

A paper was read, entitled, "Notice of a Shock of an Earthquake felt in the Island of St. Mary's, one of the Scilly Islands, on the 21st of January, 1839," in a letter addressed to the Secretary. By the Rev. George Wordley.

The tremulous motion of the ground is described as being very slight, and felt chiefly in the south parts of the island. It was accompanied by a peculiarly harsh and grating sound, which was only of momentary duration, and no particular agitation of the sea was observed.

A paper was in part read, entitled, "Observations on the Parallel Roads of Glen Roy, and of other parts of Lochabar, with an attempt to prove that they are of Marine Origin." By Charles Darwin, Esq., M.A., F.R.S., Sec. Geol. Soc.